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Knowledge Map of Facilities Management

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ABSTRACT

Purpose This paper aims to draft a knowledge map of the fragmented and multidisciplinary research of and relevant to FM. Facilities management knowledge map is a tool for presenting what relevant data and knowledge, a.k.a. knowledge, resides in different disciplines. Knowledge mapping is a step in creating an inventory of knowledge (i.e. the knowledge base) and developing/improving the processes of knowledge sharing in research, education and practice.

Theory Knowledge mapping is discussed in terms of knowledge management. The research is connected to knowledge mapping in the facilities management profession, research and education. The knowledge map aims to contrast perspectives on how to map interdisciplinary research.

Design/methodology/approach The Knowledge map is based on classification of 83 articles, including volume 2013 of Facilities (40 articles) and of Journal of Facilities Management (21 articles) and all volumes (2010-2013) of International Journal of Facility Management (22 articles), except 2013, issue 3.

Findings. The Knowledge map integrates eight different disciplines. Management is still the dominant discipline followed by engineering.

Originality/value.

Based on knowledge maps both the research community and FM-practitioners can develop new models for identifying knowledge needs and gaps and to improve knowledge sharing and knowledge flow and thus the fulfilment of their mission and goals. Knowledge maps can also help in organizing research activities and analysing of the related flow and impact of knowledge

Keywords Facilities management, Knowledge management, Knowledge mapping, Disciplines, Interdisciplinary

1 INTRODUCTION

Facilities management, FM, is developing towards an academic discipline in its own right with a focus on creating new knowledge that develop and support the competences needed by professionals within FM. To succeed in this, FM has to be a multidisciplinary and applied research field. As a professional management discipline Facilities management has developed since around 1980 starting in large corporation in the USA and is today a global profession, particularly in more developed countries. Facilities management has in the last decades gone through a paradigm shift from a narrow technical focus towards a broader management focus. (Andersen et al. 2012)

Scientific inquiry in the field of Facilities Management, FM, will increasingly be found at the boundaries of traditional disciplines. The study of complex systems, such as integration between several disciplines like management, technology and facilities, requires an approach that crosses disciplinary boundaries. FM research has its roots at the beginning of the 21st century and is discussed from perspectives of different disciplines, a development also seen in other socio-technical fields such as work organization, sociology of work, development of evidence based research in health care etc. (Nenonen and Lindahl 2012).

This paper aims to draft a knowledge map of the fragmented and multidisciplinary research of FM. Facilities management knowledge map is a tool for presenting what relevant knowledge resides in different disciplines. FM in general integrates knowledge from civil engineering, architectural planning and business management. Knowledge mapping is a step in creating an inventory of knowledge (i.e. the knowledge base), identifying knowledge needs and gaps and developing/improving the processes of knowledge sharing in research, education and practice (Tandukar 2005).

The paper presents an introduction based on the fields of FM and knowledge management, thereafter follows a section with findings from the a recent study after which comes a conclusion pointing to relevant and crucial issues for knowledge management and development within the field of FM.

2 KNOWLEDGE MANAGEMENT AND KNOWLEDGE MAPPING

2.1 Knowledge management and knowledge mapping in general

Research interest in knowledge management has grown rapidly. Much research on knowledge management is conducted in academic and industrial communities. (Suyeon et al 2003) The term -Knowledge Mapping- seems to be relatively new, but it is not. (Tandukar 2005) Knowledge mapping is a phenomena increased among the interest into organizational knowledge management. Knowledge is a set of data and information, to which is added expert opinion and experience, to result in a valuable asset which can be used or applied to aid decision-making. Knowledge may be explicit and/or tacit, individual and/or collective. Knowledge mapping is an on-going quest within an organisation to survey, audit and synthesise the knowledge within an organisation. Auditing knowledge within an organisation identifies knowledge gap, classifies, sorts and identifies the knowledge flow within the organisation. Synthesis is the ultimate stage in knowledge mapping where the processes, peoples and knowledge mapping tools are cleverly linked to each other and elucidate the relationship among them. However, the absence of

knowledge management approaches in the organisation, arguably, causes deficiency of structured and purposive knowledge mapping. (Yasin and Egbu, 2011.)

Knowledge mapping is also about processes. According to Tandukar (2005) Knowledge Map describes what knowledge is used in a process, and how it flows around the process. It is the basis for determining knowledge commonality, or areas where similar knowledge is used across multiple process. It describes who has what knowledge (tacit), where the knowledge resides (infrastructure), and how the knowledge is transferred or disseminated (social). The process of making the knowledge map is as important as the final product because its impossible to create a single map which will meet the needs of every situation.

Tandukar (2005) continues: Knowledge mapping is data gathering, survey, exploring, discovery, conversation, disagreement, gap analysis, education and synthesis. The knowledge map is a navigation aid to explicit (codified) information and tacit knowledge, showing the importance and the relationships between knowledge stores and the dynamics of knowledge utilization.

2.2 Facilities management and knowledge management

According to Lehtonen and Salonen (2006), FM has gradually become accepted as a service profession within the property and construction industries during the early 1980s. Nevertheless academic research, publications and theoretical investigation into FM did not start until the 1990s (Price and Akhalghi, 1999) and it still remains under-researched (Nutt, 1999), while procurement and relationship management are becoming increasingly important in academic FM publications (Salonen, Lehtonen & Ventovuori, 2005).

The first comprehensive review, evaluation and classification about academic research that has been published in facilities management (FM) was conducted in a European context in 2007 by Ventovuori et al. Qualitative data was gathered from academic papers published in FM-related journals (i.e. Facilities, the Journal of Facilities Management, and the Nordic Journal of Surveying and Real Estate Research – Special Series) and in conjunction with academic conferences (i.e. the European Research Symposium in Facilities Management and the CIB W70 Symposium) between 1996–2005. In this study, the research papers were classified according to the FM topics examined in them, the type of research performed and the data-gathering methods used in the study reported, the background of the authors, the research field, and the research sector. The evaluation of the academic papers indicated that the reporting of the methods used, data collection and limitations is inadequate in many academic papers. However, to draw valid conclusions and align FM research, methodological issues should be clearly delineated in research papers. In order to progress, the FM discipline must increasingly employ hypothesis testing and more robust data analysis techniques. Ventovuori et al. (2007) added a further remark that many papers could have been developed into pure research papers by referring to the existing body of knowledge. Then again, they also put forward the mitigating observation that “this is characteristic of a completely new or emerging area of research”.

The need for knowledge management has been identified both in practice and research of facilities management, for instance by Pathirage et al. (2012), who study the knowledge management practices in facilities organization by use of an intellectual capital framework. Another study was undertaken by Jensen (2009), who claims that one of the problems in the building industry is a limited degree of learning from experiences of use and operation of existing buildings. Development of professional FM can be seen as the missing link to bridge the

gap between building operation and building design. He presents a typology of knowledge transfer mechanisms from building operation to building design based on a combination of knowledge push of requirements from building operation and knowledge pull from building design. The typology is further developed in Jensen (2012) including knowledge pull of performance validation from FM and knowledge push from building construction. Knowledge transfer mechanisms have recently been studied more generally by Zuo et al. (2013). However, these studies of knowledge management practices and knowledge transfer mechanisms are concerned with how knowledge is managed, while knowledge mapping is concerned with which knowledge is needed and the characteristics of this knowledge.

2.3 Facilities management and knowledge mapping

For facilities management organisations, the question of where and how to start and what is needed to commence the knowledge mapping initiative in the organisation leave facilities managers in limbo. The literature review and survey interview amongst facilities managers in Malaysia reveal that it is crucial to identify knowledge assets in an organisation very early on. Through knowledge mapping, expected benefits can be fully exploited. Facilities managers in Malaysia realise the importance of their knowledge rich organisations being mapped. This is to ensure that they do well in the competitive business environment and gain recognition of their important role in supporting prime activities of the clients' organisations. (Fadzil Yasin¹ and Charles Egbu)

Pullen et al. (2009) continue that a lot could be learned from anthropologists always describing their own perspective. Extrapolating strengths and weaknesses, in other words, need to be on the view screen of FM researchers. Alexander (2008) has noted: “FM research should respond to the need for real world, people-centred and action-oriented concepts and tools so that facility managers can act as “reflective practitioners”. Jensen (2012a) points out that facilities management research in the different Nordic countries has developed based on local conditions and opportunities. According to Pullen et al. (2009) facilities can be seen as business resources serving organizational goals. FM studies and specifically the usability studies seem to fill this gap because they study buildings and their effects from the perspective of the built environment. In the last two decades there have been studies claiming that science is becoming ever more interdisciplinary. Science maps are used e.g. to investigate if science is becoming more interdisciplinary. Porter and Rafols (2009) claim that interdisciplinary research is developing but in small steps — drawing citations mainly from neighbouring fields and only modestly increasing the connections to distant cognitive areas.

An identified challenge in FM research, either in a multi-, inter- or a trans disciplinary approach, is to manage both collaboration between fields of research and collaboration with the business life and other third parties in order to bring the results into practice. Another challenge is related to the interpretation of research results: the problems solved may well be complex but the industry and persons in practice might still articulate and interpret the results from the perspective of mono disciplinarity.

The research process, furthermore, varies depending on different approaches. It is always demanding to collaborate with representatives from a variety of disciplines, as there is the obvious risk of being considered weak and fragmented due to lacking research rigidity. One

major challenge is, therefore, to design the research in such a way that a common language can be found. The common goal has to be shared by all representatives but the ways to achieve it can be designed differently, depending on the relevance of conducting the research in a multi-, inter- or trans disciplinary way.

In order to develop FM research and to manage the integration of methods, the research community has to engage in a discourse concerning the development of a possible FM methodology. As no method or approach is complete, the FM field will have to develop its own variety of research approaches and do that in a very conscious way. As it is not likely that specific FM research methods will develop, the capability to manage multi- and trans disciplinary approaches will be one determinant of quality within the FM research, focusing on people and spaces and how these relate both socially, economically and technically. This brings FM in the field of mixed methods approaches. Emphasis needs to be placed on the interdisciplinary nature of making patterns, as well as the collaborative construction of knowledge.

Doleman and Brooks (2011) have used grounded theory analysis to test the supposition of facility management knowledge construct in a three-phase focusing on analysing international tertiary Facility Management courses, where course content is critiqued through linguistic analysis to extract the knowledge categories. They identified 24 common knowledge concepts: 24 most common facility management knowledge categories: Management, Business, Product, Environment, Facilities, Organisation, Systems, Organisational, Change, Analysis, Financial, Customer, Planning, Quality, Interior, Marketing, Development, Communication, Process, Materials, Service, Skills, Research and Design.

Jensen (2012) claims that in research FM has to be a multidisciplinary and applied research field – it integrates Strategic Management, Change Management, Sourcing Theory and Service Innovation, Organisational Economics, Value/Supply Chain Management and Performance Management, Sustainability, Environmental Management and Real Estate Management, including Space Management.

3 TOWARDS FACILITIES MANAGEMENT KNOWLEDGE MAP

Processes of knowledge mapping have been discussed by various authors such as Kim et al. (2003), Egbu (2006), Ebner et.al (2006), Yang (2007), Grey et al (2009) and. The approaches towards knowledge mapping could be classified into three main categories that are 1) gathering and capturing knowledge, 2) analysing knowledge and 3) linking the knowledge. Beyond the three activities of knowledge mapping, Kim et al. (2003) suggest that knowledge map validation should be included.

3.1 Sample

Knowledge types used in 83 articles were from academic journals. They include volume 2013 of Facilities (40 articles) and of Journal of Facilities Management (21 articles) and all volumes (2010-2013) of International Journal of Facility Management (22 articles), excluding 2013, issue 3, which has just been published with conference papers for World Workplace 2013.

The analysed papers represented globally Facilities management studies in a following way: 25 papers were from Europe, 22 from Asia, 19 from North America, 12 from Australia and New Zealand, 4 from Africa and one from South America.

3.2 Method

The articles were analysed by a thorough scrutiny of the abstracts supplemented by a screening of each full article to understanding the use of theory and methodology etc.. For each article the following general information was collected:

- Authors
- Title
- Country (categorized by first authors)
- Purpose (as stated in abstract)
- Keywords (as stated)
- Paper type (Conceptual, Empirical, Other).

The articles were categorized according to the

- Object of study
- Focus of the paper
- Theory
- Basic discipline(s)
- Disciplinarity (Mono-, Multi-, Inter-, Trans-)

The categorization of object, focus, theory and basic discipline(s) was done without predefined categories, but more general groupings were made based on the detailed categorisation. The more detailed categorization of the research was based on the model called research ‘onion’ (Saunders et al., 2012) in a slightly adapted version with the following parameters:

- Philosophy (Positivism, Interpretism, Pragmatism)
- Approach (Deduction, Abduction and Induction)
- Methodological choice (Quantitative, Qualitative, Mixed method)
- Strategy (Survey, Archival, Case study, Literature study, Combinations)
- Time horizon (Cross-sectional, Longitudinal)
- Techniques and procedures (No predefined categories)

4 RESULTS

4.1 Background analysis

When analysing the papers by paper type, there were 17 conceptual papers and 63 empirical papers. One of the papers was opinion paper and two were more based on practice. Research philosophy used were mostly interpretism (n=33) and the positivism as philosophy was dominant in 27 papers. Pragmatism was used in 23 articles. Inductive approach was most used in the articles (n= 61). Deductive approach was mentioned in 19 articles while only two used abductive approach.

The objects of the research were grouped into 6 different types as shown in Table 1. Most papers concerned specific processes or activities like cleaning, construction and refurbishment (n=27), specific facility or industry types like education, healthcare and shopping (n=22), specific building or asset types like green buildings, historic buildings and real estate (n=15) or specific space types like psychiatric milieu, workplace and outdoors (n=13). Some paper concerned specific equipment types like ICT, building automation and air conditioning (n=5) and one paper was HR-related.

Table 1 Objects of research

Object	Facilities	JFM	IJFM	Sum
Facility/Industry type	9	8	4	22
Process/activity type	10	10	7	27
Equipment type	1	1	3	5
Space type	9	1	3	13
Buildings/assets	11	1	4	16
HR-related	0	0	1	1
Sum	40	21	22	83

The focus of the research was grouped into 5 different areas as shown in Table 2. Most papers had a management process related focus like decision making, procurement and design process (n=26), a performance related focus like building performance, energy performance and FM service performance (n=23) and an impact related performances like design impact, FM service impact and stakeholder perceptions (n=23). A number of papers had focus on special considerations like accessibility, design features and maintenance (n=9) and two papers gave research overviews.

Table 2 Focus of research

Focus	Facilities	JFM	IJFM	Sum
Impact related	16	5	2	23
Performance related	7	2	14	23
Management process related	11	9	6	26
Special considerations	4	5	0	9
Research overview	2	0	0	2
Sum	40	21	22	83

Research strategy was in 4 cases archival research. In 27 papers surveys were used, 27 papers were based on case studies and literature study was the basis of 14 papers. Additionally, two papers had both survey and case studies.

Methods were mostly mixed methods (n=34). When papers had only one method, it was qualitative by its nature in 23 papers and quantitative in 25 papers. From 71 papers it was

possible to find mentioning about the time perspective: most of the studies were cross-sectional (n=57) and only 14 represented longitudinal studies.

4.2 Analysis of Disciplines and Theories

In relation to disciplines there was no mono-disciplinary studies, thus all studies combined knowledge from two or more disciplines. Almost all were categorized at inter-disciplinary, but 3 papers concerning space management, workplace management and safety management, respectively, were seen as trans-disciplinary.

The most common combination was without comparison management and engineering (n=35), but combinations of management and psychology (n=9) and architecture and health (n=8) were also quite frequent. All together nine basic disciplines were utilized as shown in Table 3. Sustainability and environment is included as part of management and engineering.

Table 3 Basic Disciplines

Basic disciplines	Facilities	JFM	IJFM	Sum
Architecture	15	1	2	18
Economy	1	7	2	10
Engineering	22	10	8	40
Health	9	1	1	11
informatics	0	0	1	1
Management	25	17	10	52
Organisation	0	0	4	4
Psychology	7	4	3	14
Sociology	1	0	1	2
Sum	80	40	32	152

For each paper the most important theory was chosen and these were then grouped as shown in Table 4. The most common group of theory were related to performance management (n=11), incl. Post Occupancy Evaluations (POE). Theories related to green buildings, energy and sustainable FM (n=11), value management/engineering/theory (n=9), environment-behaviour (n=8), risk and safety (n=7) and design related theories (n=6) were also quite commonly applied. A number of other theories were only used once or a few times.

Table 4 Theories

Theory	Facilities	JFM	IJFM	Sum
Performance Management, inkl. POE	6	4	4	14
Green buildings, energy and sustainable FM	5		6	11
Value management/engineering/theory	8	1		9
Environment-behaviour	7	1		8
Risk and safety	1	5	1	7
Design related theories	6	0	0	6

Cost and valuation		3	1	4
Sourcing and bidding		3		3
Decision process and support	1	1	1	3
Service management and quality	2	1		3
Human factors		1	2	3
Workplace and space management			3	3
Lean management and partnering	2			2
Hygiene	1			1
Industrial management		1		1
Knowledge Management			1	1
Leadership theory			1	1
Profession			1	1
Systems thinking			1	1
Urban FM	1			1
Sum	40	21	22	83

4.3 Summary of Results

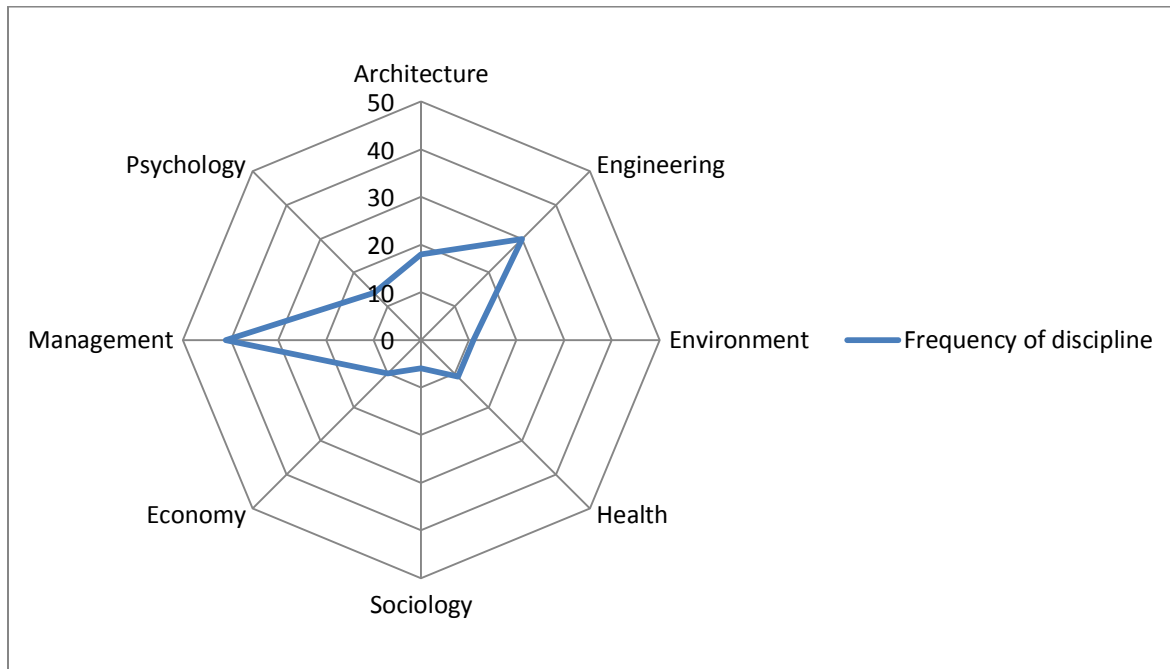
Based on table 3 but with inclusion of environment as a new basic discipline and reducing both engineering and management correspondingly and with including informatics in engineering and organization in sociology we reach a consolidated overview of basic disciplines as shown in Table 5. Management is still the dominant discipline followed by engineering.

Table 5 Disciplines mostly applied to FM

Basic disciplines	Facilities	JFM	IJFM	Sum
Architecture	15	1	2	18
Economy	1	7	2	10
Engineering, incl. informatics	17	10	3	30
Environment	5	0	6	11
Health	9	1	1	11
Management	20	17	4	41
Psychology	7	4	3	14
Sociology/organisation	1	0	5	6
Sum	70	40	20	130

The results are illustrated in the spider diagram in Figure 1 providing a knowledge map of FM with the frequency of 8 basic disciplines.

Figure 1 Disciplines mostly applied to FM



5 CONCLUSION

The facilities management knowledge map provides information about the main areas research has focused on so far. It is likely that it also points to where the research in the nearest future will be conducted. The management aspect of course also signals the focus on service management and FM organization being viewed as services rather than delivery of engineered products.

From a more structured point of view, the Knowledge Mapping sets the base for the discussion on:

- What knowledge we have in academic community of facilities management?
- What knowledge is needed (or wish we had) ?
- What knowledge should be shared and with whom?
- How will the knowledge flow process for academic and professional communities be managed?

What also is relevant to comment on is the fact that knowledge management as such is not part of the map above. As knowledge management, and behaviour, are crucial to service organization excellence this is somewhat remarkable. The field of FM is likely to need to develop a view on the knowledge base not only from thematic or factual perspectives but also from a perspective encompassing the basis for service delivery, namely knowledge about clients needs. This would best be illustrated by adding an aspect of knowledge management and in the future look more also into the areas of sociology and psychology. With an integration of FM perspectives also on communal level new challenges and issues will also arise. One such area could be issue related to participation, which also is relevant for the emerging area of evidence-based design. How do

we service evidence based designs from an FM perspective, what approach is need for a design that is tested and proven, perhaps evidence based services?

REFERENCES

- Andersen, P., Rasmussen, B. and Jensen, P.A. (2012), Future trends and challenges for FM in the Nordic Countries, In: *Facilities Management Research in the Nordic Countries: Past, Present and Future*. Eds. Jensen, P., A. and Balslev Nielsen, S. Lyngby: Polyteknisk Boghandel og Forlag, 2012, Pp. 310-320.
- Doleman, R and Brooks, D.J., A strategy to articulate the facility management knowledge categories within the built environment. *The Proceedings of the 4th Australian Security and Intelligence Conference*.
- Ebner, S., Khan, A., Shademani, R., Compernelle, B.M., Lansang, M.A. and Lippman, M. (2006), Knowledge mapping as a technique to support knowledge translation, *Bulletin of the World Health Organisation*, 84 (8), Pp. 636-642.
- Egbu, C. (2006), The Role of Knowledge Communication and Knowledge Mapping in a sustainable Urban Environment, Output of and EPSRC supported study – EP/C009649/1, Glasgow Caledonian University, Glasgow, UK.
- Grey, D. (1999), Knowledge mapping: a practical overview, <http://kmguru.tblog.com/post/98920> (site accessed on 11 September 2013).
- Jensen, P. A. (2009), Design Integration of Facilities Management: A Challenge of Knowledge Transfer. *Architectural Engineering and Design Management*, 5(3), Pp.124-135.
- Jensen, P.A. (2012), Knowledge Transfer from Facilities Management to Building Projects: A Typology of Transfer Mechanisms. *Architectural Engineering and Design Management*, 8: 170–179.
- Jensen, P. A. (2012), The making of the FM value map. In Jensen, P. A., van der Voordt, T., & Coenen, C. (Eds.), *The Added Value of Facilities Management: Concepts, Findings and Perspectives*. Pp. 44-55. Polyteknisk Boghandel og Forlag.
- Kim, S., Suh, E. and Hwang, H. (2003), Building the knowledge map: an industrial case study, *Journal of Knowledge Management*, 7(2), Pp.34-55.
- Nenonen, S. and Lindahl, G. (2012), Interdisciplinary Approaches, Obstacles and Possibilities – Experiences from Facilities Management Research. *Proceedings of EFMC 23rd - 25th of May, 2012 Copenhagen*, pp. 263-274.
- Nutt, B. (1999), Linking FM practice and research, *Facilities*, 17(1-2), Pp.11-17.
- Pathirage C., Haigh R., Amaratunga D. and Baldry .D (2008), Knowledge management practices in facilities organisations: a case study. *Journal of Facilities Management* 6(1), Pp.5–22.
- Porter, A.L., & Rafols, I. (2009), Is Science Becoming more Interdisciplinary? Measuring and Mapping Six Research Fields over Time, *Scientometrics*, 81(3), Pp.719-745.
- Price, I., & Akhlaghi, F. (1999), New patterns in facilities management: Industry best practice and new organisational theory, *Facilities*, 17(5/6), Pp.159–166.
- Pullen, W.R., Van der Voordt, T.J.M. and Hanekamp, J. (2009), Input for the 2015 FM research and action agenda, *Proceedings EFMC 2009 Research Symposium, Amsterdam, The Netherlands*.
- Salonen, A., Lehtonen, T., & Ventovuori, T. (2005), A review and classification of empirical research in facilities management, *Proceedings of the 4th European Research Symposium in Facilities Management, Frankfurt*. Pp. 477–485.

- Saunders, M.N.K., Lewis, P. and Thornhill, A. (2012), *Research Methods for Business Students* (6th edition). Harlow: Pearson.
- Suyeon Kim, Euiho Suh, Hyunseok Hwang, (2003), Building the knowledge map: an industrial case study, *Journal of Knowledge Management*, Vol. 7 Iss: 2, Pp.34 – 45
- Tandukar, D. (2005), Knowledge mapping. <http://ezinearticles.com/?Knowledge-Mapping&id=9077>. (Site accessed 10.10.2013).
- Ventovuori, T., Lehtonen, T., Salonen, A. and Nenonen, S., (2007), A review and classification of academic research in facilities management. *Facilities*, 25 (5/6). Pp. 227-237.
- Zuo, M., Zhao, D. and Gao, P. (2013), Models for Describing Knowledge Transfer Mechanisms. *Scientific Journal of Management Science and Engineering*, 3(3).
- Yang, J. B. (2007), Developing a knowledge map for construction scheduling using a novel approach, *Automation in Construction*, 16, Pp. 806-815.
- Yasin, F. and Egbu, C. (2011), Critical steps to knowledge mapping in facilities management organisation In: Egbu, C. and Lou, E.C.W. (Eds.) *Proceedings of 27th Annual ARCOM Conference*, 5-7th September 2011, Bristol, UK, Association of Researchers in Construction Management, Pp.603-612.